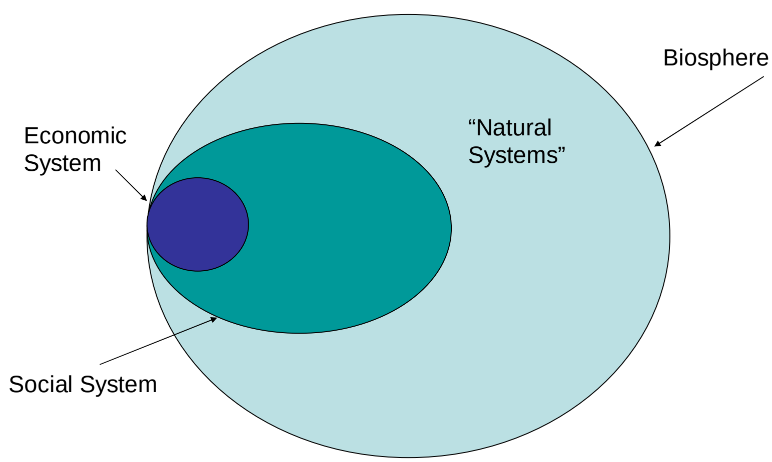
CHAPTER 2 CONCEPTUAL FOUNDATIONS FOR THE SUSTAINABLE WATER RESOURCES ROUNDTABLE

A General Framework for Understanding Sustainability

A set of underlying concepts was developed to guide the work of the Roundtable.[1] This conceptual framework includes two types of concepts: systems concepts and information concepts. Systems concepts are used to represent our understanding of "how the world works." In the case of water resources, systems concepts represent those components and processes in our world by which water moves from place to place, interacts with other components of the biosphere and is used by humans. Information concepts are used to describe ways to organize, communicate and apply information: their importance in identifying criteria and indicators is described in Chapter 3.

Figure 2.1 displays the overall relationships among three major systems (natural, social and economic) encompassed by the concept of sustainability. The Biosphere includes all living things on Earth and the non-living systems with which they interact and on which they depend. In our early work we used the term "Natural Systems" for the ecosystem. The Social System includes all the human elements of the Biosphere. The Economic System is embedded within the Social System. The concept of sustainability as a property of the biophysical system that emerges from interactions between the ecosystem and society is attractive to experts and managers in many fields.

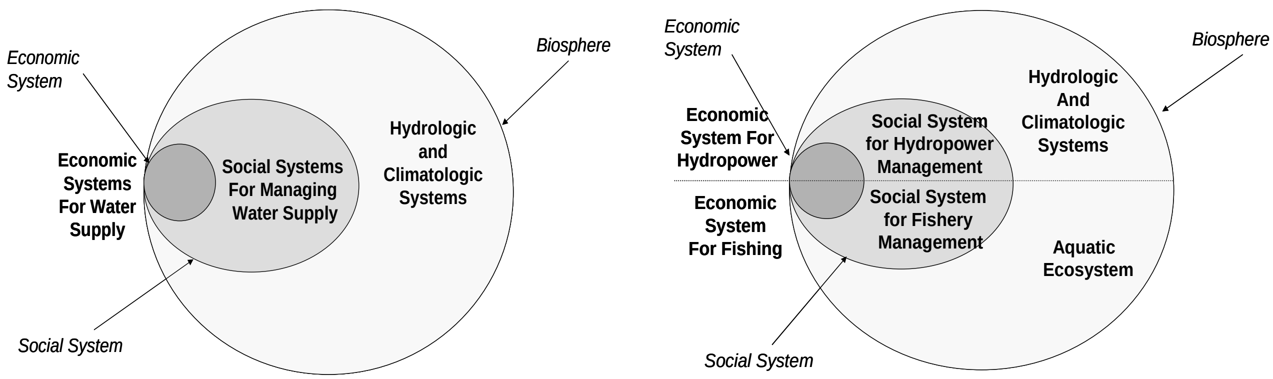
Figure 2.1
General Systems Perspective



One way to use systems concepts to identify effective indicators is to recognize that sustainability can be achieved by maintaining capital or capacities to meet various human and non-human needs within the biosphere. Economists regard capital as the capacity to produce a flow of value over an extended time – value produced by satisfying human needs. Although capital is most often identified with economics, it is also used for other types of analysis. All three systems – natural, social, and economic – produce flows of services, experiences, or goods that meet various needs over time. Thus, all three contain capital. Indicators measure this capital and the direct and indirect impacts caused by changes in capital over time.

Ultimately, our indicator framework should enable characterization of the relations between system processes and impacts on natural and human conditions over time. Figure 2.2 provides examples of the use of the general concepts in Figure 2.1 to describe relationships among the systems involved in producing hydropower and fish.

Figure 2.2
General Systems Perspective
Examples of Hydro and Fish



Major Categories of Indicators

Based on our understanding of the larger context of sustainability, the SWRR held a series of meetings to identify major categories in which to group indicators. Figure 2.3 shows the results.

Figure 2.3
Major Categories of Indicators

I. System Capacities and Their Allocation

2. Consequences of Water Allocation

3. Effects on People

4. Underlying Processes and Driving Forces

These four categories organize indicators logically in accordance with the most generally accepted concepts of sustainability. They include:

1. ***System capacities and their allocation***: Water resources capacities and their allocation to different uses and functions;

2. ***Consequences of water allocation***: The consequences of water allocation, including environmental conditions, and human uses of withdrawn water and water dependent resources;

3. ***Effects on people***: The effects of those consequences on human conditions; and

4. ***Underlying processes and driving forces***: Key processes and driving forces underlying these capacities, allocations, consequences and effects.

A key focus of SWRR's framework is the allocation of water between withdrawals for human use and the water in the environment as it is affected by withdrawals and return flows. The quality of water in the environment is affected by environmental processes, return flows from human uses of water, and the wastes and residuals from human activities. Water resources management determines this allocation which draws upon the capacity of the environmental system to make water available (gross availability) and the capacity of the infrastructure to withdraw and deliver water for various uses

The framework is also based on the concept that many different approaches to sustainability embrace the long-term maintenance of capacities, such as the capacities to meet human needs and the capacities to support life in the ecosystem. They also reflect that water resources management focuses on both human and environmental conditions.

Collectively, the categories resemble an accounting system covering both environmental and human components of water resources systems. They are designed to track important stocks and flows, or, in economic terms, assets and income. Capacities are stocks of water, flow capacities, or assets related to water, whereas water usage and its effects on people and the environment are flows, just as income is a flow. The categories can account for stocks and flows of water and for the human assets and benefits associated with the use of water or water dependent resources. The categories also provide a consistent way of accounting for environmental conditions that result from the interactions of hydrologic and biologic processes and human activities.

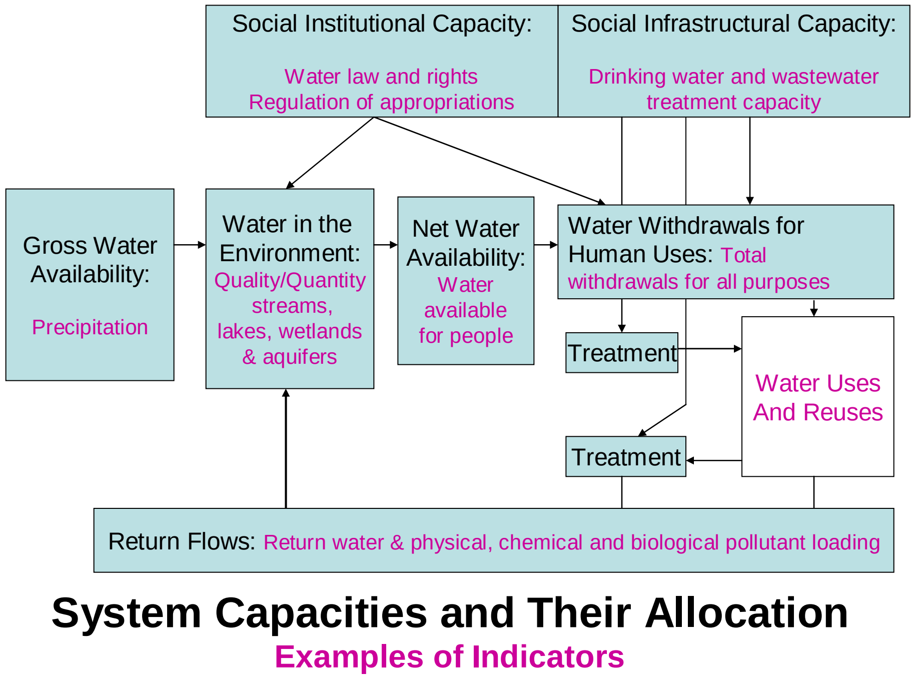
The SWRR's conceptual framework of indicators is not a complete systems model. Instead the framework represents the primary relationships among the four categories of key indicators and is a good way to organize complex information. It is consistent with discussions that have taken place among all four resource roundtables in their respective Integration and Synthesis Groups (ISG). The ISG Framework was developed to provide a basis for integration of indicators from other roundtables and indicator projects.[1]

Each of the four categories and example indicators are discussed below.

Systems Capacities and Their Allocations

Category 1 focuses on the capacities of the hydrologic cycle and human-built infrastructure, as well as social and economic capacities for managing and using water. The capacities and examples of indicators are shown in Figure 2.4

Figure 2.4
System Capacities and Their Allocation, Examples of Indicators

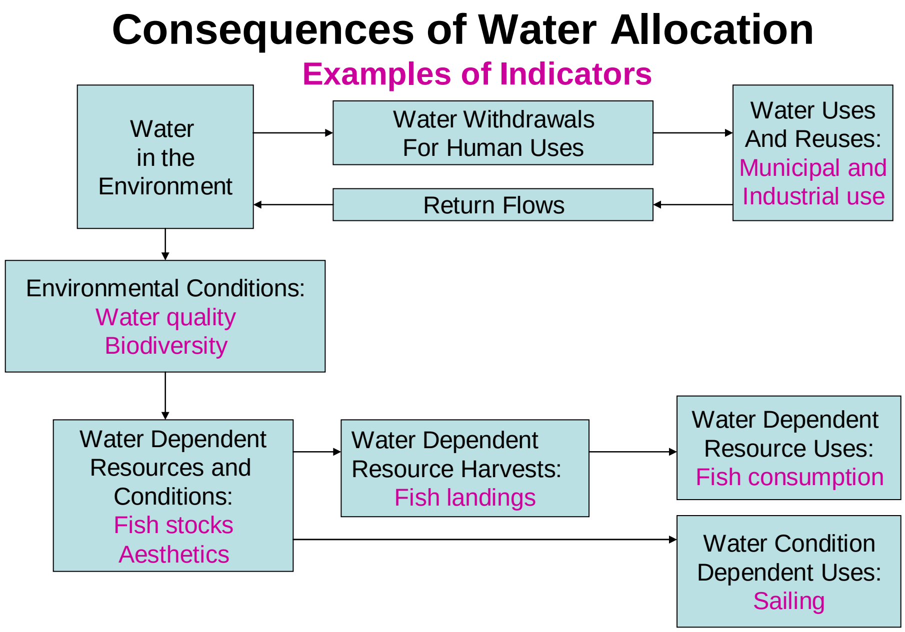


The availability of water for various uses depends on the types of flows that are a part of the hydrologic cycle and on the stocks of water from which humans can draw. In short, this is a water budget approach. A key feature of this category of indicators is the focus on allocation of water to different uses. Human-built capacities to withdraw, treat, transport, distribute and use water and to use it for transportation and recreation would also be addressed in this category.

Consequences of Water Allocation

The second category focuses on the consequences of water allocation for both human uses and the environment. Figure 2.5 shows major components and example indicators.

Figure 2.5
Consequences of Water Allocations, Examples of Indicators

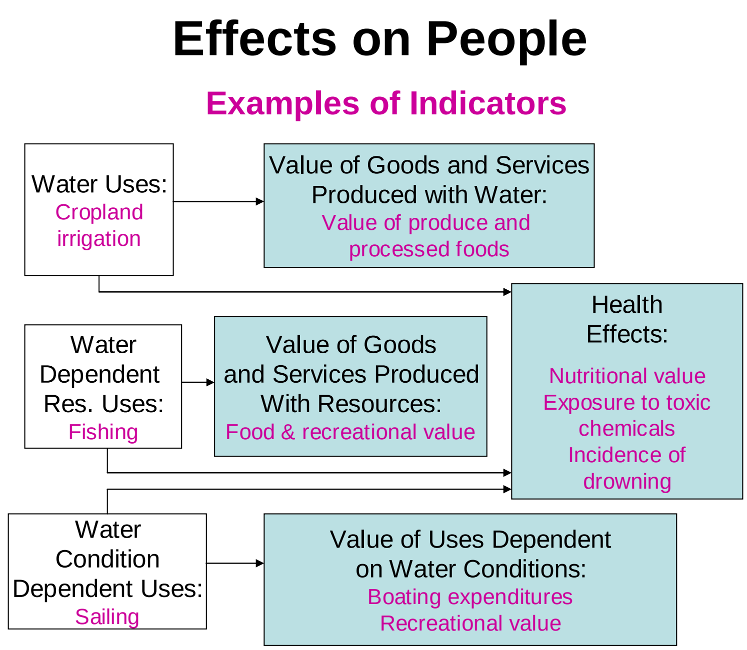


Note that this category includes elements from the first category, such as "Water in the Environment" since it is affected by withdrawals and return flows. Water in the environment is also affected by flows over land surfaces managed or altered by humans. As a result, this category includes both water quality and other environment conditions that are affected by withdrawals, return flows, and discharges of wastes and residuals from human activities. This major category also includes indicators of Water Dependent Resources and Conditions, of Harvests of such resources and their uses, and of the uses that are dependent on in situ water conditions.

Effects on People

While the second category involves measuring the consequences of water allocation in environmental or physical terms, the third category focuses on accounting for the effects on people. These are shown in Figure 2.6 Elements from Figure 2.5 are carried forward into Figure 2.6.

Figure 2.6
Effects on People



Incidence People are affected by their direct use of water for drinking, cooking, and sanitation. They are also affected by their use of a wide range of goods and services produced using water. These include irrigated crops, food products, thermo-electric and hydro-electric power, and a wide variety of manufactured goods. People are also affected by use of water dependent resources that are extracted, such as fish and cranberries. And finally, people are affected by uses of water that depend on its in situ conditions such as recreation and transportation. The indicators in this category focus on the value people experience from uses of water, water dependent resources, and water conditions. They also focus on water-related health effects on people.

Underlying Processes and Driving Forces

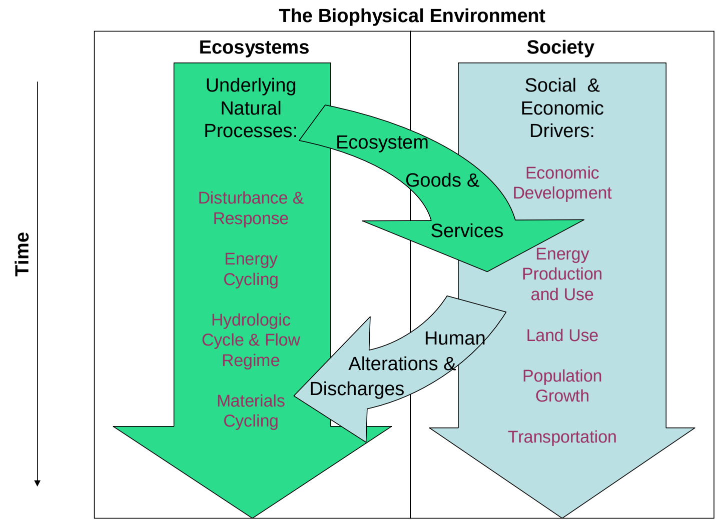
The fourth category recognizes that there are important underlying or driving forces that affect the capacities of water resource systems and the environmental and human conditions that result from those capacities. These include human population and economic growth, land use patterns, residual flows and waste discharges, and climate. It derives from an understanding of systems interrelationships shown in Figure 2.1.

Summary

In summary, the extent to which water resources, as currently managed and used by humans, contribute to sustainability can be assessed by considering trends in the ecological, economic and social capacities and conditions that are related to water resources as well as trends in their short-term contributions to meeting human needs and wants.

The indicators in the major categories outlined by the SWRR can provide the information for good assessments. In general, if important ecological, economic and social capacities that are dependent on, or closely related to, water resources are declining substantially over extended periods of time, it would be important to analyze the causes of the trends to evaluate whether they are driven by the natural variability of the system or by management that does not contribute to sustainability.

Figure 2.7
General Framework for Driving Forces and Underlying Processes



In making such an assessment, it is important to consider that sustainable systems are dynamic and enduring. Therefore, the assessment should identify long-term trends and should consider the extent to which trends of possible concern are being offset, or adapted to, by other elements of the systems. Figure 2.7 is a simplified summary of the Driving Forces and Underlying Processes that make up some of the dynamics of society’s interaction with the biophysical environment that includes some of the main variables such as population growth and land use.

It is also worth noting that care should be taken when good measures of capacity are not available and attention is shifted to measuring either current performance or processes that cause changes in capacity. Because such measures are indirect indicators of capacity, they may not give a realistic picture of capacity trends. For example, some processes on which capacity depends are able to continue at a fairly constant level of performance until a tipping point is reached, after which performance and capacity decline sharply.

As the above models illustrate, relationships among elements of the ecosystem, economic and social system are complex. Population, income, land use, climate change, and energy use are key conditions that affect water allocation. They are major drivers of trends in water supply, demand, quality and therefore sustainability and are so broad that they may be overlooked when the focus is narrowed to a particular indicator related to water. Given our conceptual understanding of the relationships between system processes and impacts on natural and human complex interrelationships, the SWRR developed a list of nearly 400 candidate indicators, which are shown in Appendix C. As a result, the SWRR identified specific criteria to identify a sample of the most effective indicators. These selection criteria are presented in the following chapter.

End Notes

1. Kranz, R., S. Gasteyer, H.R. Heintz Jr, R. Shafer, and A. Steinman. 2004. Conceptual Foundations for the Sustainable Water Resources Roundtable. *Water Resources Update.* 127:11-19. http://www.ucowr.siu.edu/updates/127/Kranz.pdf

2. http://www.sustainableforests.net/docs/ISG%20Progress%20Report%20041101.pdf

Water is a vital commodity, common value, and shared responsibility. What continues to change over time, is not the drive to sustainably meet human needs to ensure respective definitions of well-being, but the way we characterize our needs, wants, and desires, and the way we approach our 'work'…sustainable development. Members of the SWRR have served the nation well in developing shared Criteria and Indicators to characterize and frame key conditions and trends of sustainable water resources.

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